Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

COPY

2

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

AD-A219 908

1a. REPORT SECURITY CLASSIFICATION: UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release; distribution unlimited.
2b. DECL	
4. PERFO	5. MONITORING ORGANIZATION REPORT NUMBER(S): AFOSR-TR- 90-0359
6a. NAME OF PERFORMING ORGANIZATION: University of California / 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION: Air Force Office of Scientific Research/NL
6c. ADDRESS (City, State, and ZIP Code): Santa Barbara, CA 93106	7b. ADDRESS (City, State, and ZIP Code): Building 410, Bolling AFB, DC 20332-6448
8a. NAME OF FUNDING/SPONSORING ORGANIZATION: AFOSR / 8b. OFFICE SYMBOL (If applicable): NL	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: AFOSR-87-0230
8c. ADDRESS (City, State, and ZIP Code): Building 410, Bolling AFB, DC 20332-6448	10. SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO. 61102F; PROJECT NO. 2313; TASK NO. A4; WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

Hand Shaping: A Paradigm for Cognitive/Motoric Interaction (Unclassified)

12. PERSONAL AUTHOR(S)

Roberta L. Klatzky & James W. Pellegrino

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
FINAL	FROM 7/1/87 TO 12/31/89	February 10, 1990	5

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	motor responses, hand shapes, priming, response timing
05	09		

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The research efforts during the contract period resulted in three submitted or published papers and one doctoral dissertation. The papers reported (i) a series of experiments demonstrating that activation of a hand-shape representation could facilitate subsequent judgments about actions on objects; (ii) an investigation of preshaping during responses to objects; and (iii) the development of a controlled object-display system to measure response time and movement time. The dissertation reported a series of experiments demonstrating that priming of a hand shape was disrupted by simultaneous preparation for a sequence of finger responses, but not by preparation for a sequence of spoken syllables. In general, our results suggest a cognitive/motoric representation of the hand with which actions on objects can be internally modeled, and which may serve a preparatory role in performance.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT: ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL: Dr. Alfred R. Fregly	22b. TELEPHONE (Include Area Code): 202/767-5021 / 22c. OFFICE SYMBOL: NL

DD Form 1473, JUN 86 — Previous editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE: UNCLASSIFIED

90 03 28 175

DTIC ELECTE MAR 29 1990 E

5 MAR 1990

Summary

The research efforts during the contract period (7/1/87-12/31/89) resulted in three submitted or published papers. The papers reported (i) a series of experiments demonstrating that activation of a hand-shape representation could facilitate subsequent judgments about actions on objects; (ii) an investigation of preshaping during responses to objects; (iii) the development of a controlled object display system to measure response time and movement time. A doctoral dissertation was also supported during the project period.

I. Specific Research Accomplishments

(1) Priming of Hand Shapes

This series of experiments has previously been reported in detail (Annual Technical Report, 1987-88). Five experiments assessed whether priming a hand shape would facilitate judgments about the sensibility of actions performed with objects. Primes specified the hand shape's functional size and flexion/extension of the fingers. Subjects were initially trained to enact the shape, given a prime, or they were trained to vocalize the name of the shape (e.g., "pinch"). They then judged the sensibility of verbal action/object pairs, such as "eat a carrot," which were preceded by a neutral or informative prime. Response times were consistently reduced when both dimensions of the hand shape were primed -- but only for subjects trained to enact the shape. No priming effect resulted after vocal training. These results suggest a cognitive/motoric representation of the hand with which actions on objects can be modeled.

(2) Preshaping for Functional Responses to Objects

This study explored the unfolding of hand-shaping in the context of functional responding to common objects. The principal issue was whether distinct, identifiable preshapes are evidenced in preparation for four distinct types of hand contact, including nonprehensile as well as prehensile hand shapes, and for small and large surfaces of contact. Previous studies of preshaping have largely concentrated on the full handed grasp, which we have termed the "clench," with some attention to pointing (the "poke" in our terminology). In addition, most such studies have occurred under circumstances where subjects could anticipate the grasped object, and where there was no attempt to simulate a real-world functional response. To isolate planning for the action as well as preshaping, we precluded the subject from observing the target object or knowing the relevant shape in advance of responding.

As noted above, our interest was in whether preshapes would be observed for all four classes of terminal hand shape, and if so, how the timecourse of preshaping would compare across the four

shapes. Accordingly, we videotaped subjects as they reached for common objects in order to functionally interact with them. The tapes were scored for the time of critical features of preshaping, as well as the onset of movement and the time to contact. Videotaped records provided a straightforward way of addressing the questions of interest, because the present hand shapes are defined as configurations in a hand coordinate space (e.g., right angle between thumb and index finger; parallel fingers). These features were reliably coded.

All four shapes considered here did in fact evidence distinct preshapes. The timecourse for those preshapes was very similar, relative to the onset of reaching. That is, the initial separation of the fingers, formation of first identifiable preshape feature, and completion of the preshape appeared at essentially the same time relative to the onset of reaching for all four shapes. The hand shapes did differ, however, in the time between the completion of a stable preshape and contact with the object. The time for preshape-to-contact was greater for hand shapes with small surfaces of contact than those with large surfaces, and for prehensile shapes than for nonprehensile. We attribute these differences to the precision required for the ultimate response, as is consistent with kinematic studies where arm velocity is measured. Our data were in accord with previous observations, in that the preshape was completed at about the midpoint of reaching, and the variable latency to object contact occurred beyond that point. We assume this would incorporate the bulk of the deceleration phase, given the typical movement profile.

(3) Measuring Reaction Time and Movement Time while Reaching for Real Objects

In order to account for both the fluency and flexibility of skilled movement, researchers in the area of human movement have developed the idea of a motor program, a central representation of an action or action sequence that contains information about how that action should be carried out. In theory, a program has two essential characteristics: It is <u>abstract</u>, in that it does not contain information specific to certain effectors (e.g., the muscle fibers of the right hand), but rather contains general instructions that are applicable to a number of different effectors. Second, it is <u>parametric</u>; that is, certain aspects of the movement can be altered (e.g., speed, force, distance, or location of a reaching movement) within a single program.

We have developed a theoretical model of hand shaping for functional interaction that incorporates the fundamental ideas of a motor program, in that we assume that a general category of hand shape (e.g., full-hand grasp) is selected, then parameterized for object contact. Whereas considerable parameterization may take place on-line, during reaching, hand-shape selection should be completed in advance of reach initiation.

For our model, and any other that separates selection from parameterization (or planning from control), it is essential to devise methods of empirically separating planning and movement. We have designed an instrument that provides such empirical separation. Specifically, it divides the course of reaching for functional interaction with objects into two timed periods: the time between exposure to the object and initiation of the reach (liftoff), and the time between initiation of the reach and contact with the object. These are generally called reaction time (RT) and movement time (MT), respectively. While others have separated these components, for example, in simple finger flexion and wrist flexion/extension, our instrument provides for such separation in the context of unconstrained, functional object interaction.

Several methodological problems arising from this methodology lead to the development of the apparatus: We needed to (1) present real, manipulable objects, not just computer images of objects; (2) present these objects virtually instantaneously, giving an accurate starting point for timing; (3) accurately mark the point in time that contact with the object was made; (4) do all this with minimal interference with the subject's natural movements; and (5) do it relatively economically.

This project led to the design of an apparatus for measuring reaction times and movement times involved in reaching for real objects. Subjects view an object through a liquid crystal (LC) window, which serves as a shutter that can be made clear or opaque quickly (10 ms from opaque to clear, 30 ms from clear to opaque). The subject's hand rests on a home key, and the object sits on a force-sensitive platform so that initiation of reach and time of contact with the object can be marked accurately. The apparatus interfaces with an IBM PC/AT through a digital I/O parallel port, so that reaction times and movement times are recorded automatically.

In a typical trial, a subject, seated with the head behind the LC window, rests the right hand on the home key, which is attached to a microswitch. The LC window is in an opaque state at this point. A warning tone alerts the subject that the trial will start. An output from the computer causes the window to change to a transparent state and a lamp to be illuminated, exposing the object on a platform. The subject reaches for the object, releasing the home key and hence signaling the computer. Contact with the object activates a piezoelectric crystal under the platform, which signals the end of the trial to the computer. The computer immediately outputs a signal that again makes the screen opaque and shuts off the lamp. A timer records the point in time of object exposure (t_0), release of the microswitch (t_1, or liftoff), and piezo activation (t_2, or contact), resulting in two time durations: reaction time, defined as the time between exposure and liftoff, and movement time, the time between liftoff

and contact.

The instrument we have designed is essentially a one-field tachistoscope, but for real objects. It is therefore a versatile means of presenting stimuli for the ecologically valid responses of reaching and grasping. It could be combined with kinematic measurement systems, if fine-grained position/time functions were desired, or with electromyography. The basic apparatus can also be modified in a variety of ways; for example, we have added a voice key so response times for tasks like a same/different judgement can be recorded. A second microswitch has also been added to allow for reaching by either hand.

(4) Motor Planning and Semantic Sensibility Judgments

In a variant on the priming paradigm described under (1) above, subjects either were requested to make a semantic sensibility judgment about some phrase describing an action of the hand, or they were signaled to perform in a secondary task. The secondary task involved either a sequential finger-press response (right forefinger, left forefinger, right middle finger, left middle finger) or a pronunciation response (saying "bah gah gee bee") that had been matched with the finger sequence for difficulty.

On each trial, either a neutral signal or a hand-shape prime symbol appeared. It was followed either by a phrase to be judged for sensibility, or a signal to perform the secondary task. Subjects did not know in advance of the trial whether they would be judging a phrase or performing the secondary task.

Under these circumstances, the priming effect was eliminated for subjects whose secondary task was manual. However, those whose secondary task was vocal showed a substantial priming effect. These results support our assumption of a cognitive/motoric representation of the hand that can be used to internally model manual interaction. Preparation for a manual response apparently interfered with that representation, whereas preparation for a vocal response did not.

II. Published and planned articles

Klatzky, R. L., Pellegrino, J. W., McCLoskey, B. P., & Doherty, S. Can you squeeze a tomato? The role of motor representations in semantic sensibility judgments. Journal of Memory and Language, 1989, 28, 56-77. (published)

Pellegrino, J. W., Klatzky, R. L., & McCloskey, B. P. Timecourse of preshaping for functional responses to objects. Journal of Motor Behavior, 1989, 21, 307-316. (published)

Fikes, T., Klatzky, R. L., Pellegrino, J. W., Hebert, C., &

Murdock, L. Measuring reaction time and movement time while reaching for real objects. Behavior Research Methods, Instrumentation, and Computers. (submitted)

McCLoskey, B., Pellegrino, J. W., & Klatzky, R. L. Motor Interference in Semantic Sensibility Judgments. Planned for submission to J. Exp. Psychology: Human Perception and Performance.

III. Presentations

Motor response categories and knowledge about objects. Presented by B. McCloskey at APA Convention, Atlanta, August 1988.

Cognitive representation of hand shapes for functional object interaction. Presented by R. Klatzky at Meeting on Theoretical Issues in Motor Control, sponsored by International School for Advanced Studies, Trieste, Italy, July 1989.

Submitted for presentation at APA Convention, 1990: Motor Interference with Semantic Judgments. (to be presented by B. McCloskey)

IV. Participating Professionals

Roberta L. Klatzky, Principal Investigator
James W. Pellegrino, co-Principal Investigator
Brian P. McCloskey, Graduate Assistant
Thomas W. Fikes, Graduate Assistant
Sally Doherty, Research Associate (1987-88)

V. Degrees Awarded

Ph.D. awarded to Brian P. McCloskey, December 1989
Thesis title: Evidence for Motor Interference in Semantic Sensibility Judgments